# PATENT ABSTRACTS OF JAPAN

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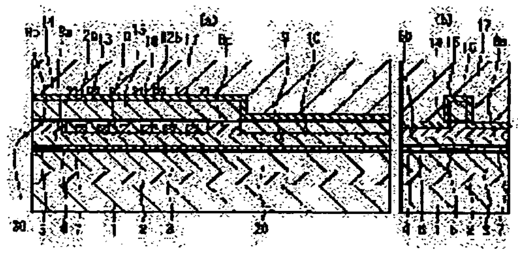
## (54) THIN-FILM MAGNETIC HEAD AND ITS PRODUCTION

(57)Abstract:

PROBLEM TO BE SOLVED: To enable the reduction of the track width of an induction type magnetic converting element and the reduction of a magnetic path length.

SOLUTION: The thin-film magnetic head has a reproducing head and a recording head. The recording head has lower magnetic pole layers 8a to 8c and upper magnetic pole layers 15 including magnetic pole portions facing each other via magnetic gap layers 14 and thin-film coils 12a and 12b which partly pass therebetween and helically wound around the upper magnetic pole layers 15. The lower magnetic pole layers 8 have the first portion 8a arranged in the region inclusive of the region facing the first layer portion 12a of the thin-film coils 12a and 12b and the second portion 8b which is connected to the surface on the upper magnetic pole layer 15 side in the first portion 8a and forms the magnetic pole portion. The first layer portion 12a of the thin-film coils 12a and 12b is arranged alongside the second portion 8b. The first layer portion 12b of the thin-film coils is formed via an insulating film 16 on the upper magnetic pole layer 15.



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CLAIMS

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[Claim(s)]
[Claim 1] It is the thin film magnetic head which is equipped with the following and characterized by arranging some aforementioned thin film coils in the side of the 2nd portion of the 1st magnetic layer of the above. The 1st and 2nd magnetic layers which consist of at least one layer including the magnetic pole portion which the part of the side which is connected magnetically and counters a record medium counters mutually through a record gap layer, respectively. It is the 1st portion to which it has the thin film coil which the part passed through between the above 1st and the 2nd magnetic layer, and was spirally wound focusing on one [ at least ] magnetic layer in the state where it insulated to the above 1st and the 2nd magnetic layer, and the 1st magnetic layer of the above counters some aforementioned thin film coils. The 2nd portion which is connected to the field by the side of the magnetic layer of the above 2nd in the 1st portion of the above, and forms a magnetic pole portion.
[Claim 2] The aforementioned thin film coil is the thin film magnetic head according to claim 1 characterized by having the portion spirally wound focusing on the 2nd magnetic layer of the above.
[Claim 3] The 2nd magnetic layer of the above is the thin film magnetic head according to claim 1 characterized by having the magnetic pole partial layer which forms a magnetic pole portion, and the yoke partial layer which is connected to this magnetic pole partial layer, and forms a yoke portion.
[Claim 4] The thin film magnetic head according to claim 3 characterized by providing the following. The aforementioned thin film coil is the 1st portion which passed through the side of the 2nd portion of the 1st magnetic layer of the above, and was spirally wound focusing on the 2nd magnetic layer of the above. The 2nd portion which passed through the side of the magnetic pole partial layer of the 2nd magnetic layer of the above, and was spirally wound focusing on the 2nd magnetic layer of the above.
[Claim 5] The thin film magnetic head according to claim 3 characterized by providing the following. The aforementioned thin film coil is the 1st portion which passed through the side of the 2nd portion of the 1st magnetic layer of the above, and was spirally wound focusing on the 1st magnetic layer of the above. The 2nd portion which passed through the side of the magnetic pole partial layer of the 2nd magnetic layer of the above, and was spirally wound focusing on the 2nd magnetic layer of the above.
[Claim 6] The end face of the side which counters the record medium of the yoke partial layer of the 2nd magnetic layer of the above is the thin film magnetic head according to claim 3 to 5 characterized by being arranged in the position distant from the field which counters the record medium of the thin film magnetic head.
[Claim 7] The thin film magnetic head according to claim 1 to 6 characterized by for the 2nd portion of the 1st magnetic layer of the above specifying throat height, and the 2nd magnetic layer of the above specifying recording track width of face.
[Claim 8] Furthermore, the thin film magnetic head according to claim 1 to 7 characterized by having the insulating layer to which some thin film coils arranged in the side of the 2nd portion of the 1st magnetic layer of the above were covered, and flattening of the field by the side of the

aforementioned record gap layer was carried out.
[Claim 9] Furthermore, the thin film magnetic head according to claim 1 to 8 characterized by having the 1st for being arranged so that a magnetic resistance element and the part of the side which counters a record medium may counter on both sides of the aforementioned magnetic resistance element, and shielding the aforementioned magnetic resistance element, and the 2nd shield layer.
[Claim 10] The 1st magnetic layer of the above is the thin film magnetic head according to claim 1 to 9 characterized by serving as the shield layer of the above 2nd.
[Claim 11] The 1st and 2nd magnetic layers which consist of at least one layer including the magnetic pole portion which the part of the side which is connected magnetically and counters a record medium counters mutually through a record gap layer, respectively. The thin film coil with which a part passes through between the above 1st and the 2nd magnetic layer in the state where it insulated to the above 1st and the 2nd magnetic layer. The process which is the manufacture method of the thin film magnetic head equipped with the above, and forms the 1st magnetic layer of the above, In the process which forms the aforementioned record gap layer on the 1st magnetic layer of the above, the process which forms the 2nd magnetic layer of the above on the aforementioned record gap layer, and the state where it insulated to the above 1st and the 2nd magnetic layer So that a part may pass through between the above 1st and the 2nd magnetic layer and it may be spirally wound focusing on one [ at least ] magnetic layer The process which forms the 1st magnetic layer of the above including the process which forms the aforementioned thin film coil It connects with the field by the side of the magnetic layer of the above 2nd in the 1st portion which counters some aforementioned thin film coils, and the 1st portion of the above. The process which forms the 2nd portion which forms a magnetic pole portion, and forms the aforementioned thin film coil is characterized by forming a thin film coil so that some aforementioned thin film coils may be arranged in the side of the 2nd portion of the 1st magnetic layer of the above.
[Claim 12] The process which forms the aforementioned thin film coil is the manufacture method of the thin film magnetic head according to claim 11 characterized by forming the thin film coil which has the portion spirally wound focusing on the 2nd magnetic layer of the above.
[Claim 13] The process which forms the 2nd magnetic layer of the above is the manufacture method of the thin film magnetic head according to claim 11 characterized by forming the magnetic pole partial layer which forms a magnetic pole portion, and the yoke partial layer which is connected to this magnetic pole partial layer, and forms a yoke portion.
[Claim 14] The 1st portion which the process which forms the aforementioned thin film coil passed through the side of the 2nd portion of the 1st magnetic layer of the above, and was spirally wound focusing on the 2nd magnetic layer of the above, The manufacture method of the thin film magnetic head according to claim 13 characterized by forming the 2nd portion which passed through the side of the magnetic pole partial layer of the 2nd magnetic layer of the above, and was spirally wound focusing on the 2nd magnetic layer of the above.
[Claim 15] The 1st portion which the process which forms the aforementioned thin film coil passed through the side of the 2nd portion of the 1st magnetic layer of the above, and was spirally wound focusing on the 1st magnetic layer of the above, The manufacture method of the thin film magnetic head according to claim 13 characterized by forming the 2nd portion which passed through the side of the magnetic pole partial layer of the 2nd magnetic layer of the above, and was spirally wound focusing on the 2nd magnetic layer of the above.
[Claim 16] The process which forms the 2nd magnetic layer of the above is the manufacture method of the thin film magnetic head according to claim 13 to 15 characterized by arranging the end face of the side which counters the record medium of the yoke partial layer of the 2nd magnetic layer of the above in the position distant from the field which counters the record medium of the thin film magnetic head.
[Claim 17] The process which the process which forms the 1st magnetic layer of the above forms the 1st magnetic layer so that the 2nd portion of the above may specify throat height, and forms the 2nd magnetic layer of the above is the manufacture method of the thin film magnetic head according to claim 11 to 16 characterized by forming the 2nd magnetic layer so that the

2nd magnetic layer of the above may specify recording track width of face.
[Claim 18] Furthermore, the manufacture method of the thin film magnetic head according to claim 11 to 17 characterized by including the process which forms the insulating layer to which some thin film coils arranged in the side of the 2nd portion of the 1st magnetic layer of the above were covered, and flattening of the field by the side of the aforementioned record gap layer was carried out.
[Claim 19] Furthermore, the manufacture method of the thin film magnetic head according to claim 11 to 18 characterized by including the process which forms the 1st for being arranged so that a magnetic resistance element and the part of the side which counters a record medium may counter on both sides of the aforementioned magnetic resistance element, and shielding the aforementioned magnetic resistance element, and the 2nd shield layer.
[Claim 20] The 1st magnetic layer of the above is the manufacture method of the thin film magnetic head according to claim 11 to 19 characterized by serving as the shield layer of the above 2nd.

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[Translation done.]

## DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the thin film magnetic head which has an induction-type MAG sensing element at least, and its manufacture method.
[0002]
[Description of the Prior Art] In recent years, the improvement in a performance of the thin film magnetic head is called for with improvement in the field recording density of a hard disk drive unit. The compound-die thin film magnetic head of the structure which carried out the laminating of the reproducing head which reads as the thin film magnetic head with the recording head which has an induction-type MAG sensing element for writing, and has the magnetic-reluctance (it is hereafter described also as MR (Magneto-resistive).) element of business is used widely.
[0003] By the way, in order to raise recording density among the performances of a recording head, it is necessary to raise the track density in a magnetic-recording medium. It is necessary to realize the recording head of the ** truck structure which narrowed width of face in the pneumatic bearing side of the lower magnetic pole formed in the upper and lower sides on both sides of the record gap layer, and an up magnetic pole from several microns to the submicron size, and for that, in order to attain this, semiconductor processing technology is used.
[0004] Here, with reference to drawing 14 or drawing 17 , an example of the manufacture method of the compound-die thin film magnetic head is explained as an example of the manufacture method of the conventional thin film magnetic head. In addition, in drawing 14 or drawing 17 , (a) shows a cross section perpendicular to a pneumatic bearing side, and (b) shows the cross section parallel to the pneumatic bearing side of a magnetic pole portion.
[0005] By this manufacture method, first, as shown in drawing 14 , the insulating layer 102 which consists of an alumina (aluminum 2O3) is deposited by the thickness of about about 5-10 micrometers on the substrate 101 which consists of ARUTIKKU (aluminum 2O3, TiC). Next, the lower shield layer 103 for the reproducing heads which consists of a magnetic material is formed on an insulating layer 102.
[0006] Next, on the lower shield layer 103, the spatter deposition of the alumina is carried out at the thickness of 100-200nm, and the lower shield gap film 104 as an insulating layer is formed. Next, the MR element 105 for reproduction is formed on the lower shield gap film 104 at the thickness of dozens of nm. Next, the electrode layer 106 of the couple electrically connected to the MR element 105 is formed on the lower shield gap film 104.
[0007] Next, the up shield gap film 107 as an insulating layer is formed on the lower shield gap film 104 and the MR element 105, and the MR element 105 is laid underground in the shield gap film 104,107.
[0008] Next, on the up shield gap film 107, it consists of a magnetic material and the lower [ an up shield layer-cum-] magnetic pole layer (it is hereafter described as a lower magnetic pole layer.) 108 used to the both sides of the reproducing head and a recording head is formed at the thickness of about 3 micrometers.
[0009] Next, as shown in drawing 15 , the record gap layer 109 which consists of an insulator layer, for example, an alumina film, is formed on the lower magnetic pole layer 108 at the

thickness of 0.2 micrometers. Next, for magnetic-path formation, the record gap layer 109 is ***********ed partially and contact hole 109a is formed. Next, the up magnetic pole chip 110 which consists of a magnetic material for recording heads is formed on the record gap layer 109 in a magnetic pole portion at the thickness of 0.5-1.0 micrometers. At this time, the magnetic layer 119 which consists of a magnetic material for magnetic-path formation is simultaneously formed on contact hole 109a for magnetic-path formation.

[0010] Next, as shown in drawing 16 , the record gap layer 109 and the lower magnetic pole layer 108 are ***********ed by ion milling by using the up magnetic pole chip 110 as a mask. As shown in drawing 16 (b), the structure where some each side attachment walls of an up magnetic pole portion (up magnetic pole chip 110), the record gap layer 109, and the lower magnetic pole layer 108 were perpendicularly formed in the self-adjustment target is called trim (Trim) structure.

[0011] Next, the insulating layer 111 which consists of an alumina film is formed in the whole surface at the thickness of about 3 micrometers. Next, it grinds and flattening of this insulating layer 111 is carried out until it reaches the front face of the up magnetic pole chip 110 and a magnetic layer 119.

[0012] Next, the thin film coil 112 of the 1st layer for the recording heads of an induction type which consists of copper (Cu) is formed on the insulating layer 111 by which flattening was carried out. Next, a photoresist layer 113 is formed on an insulating layer 111 and a coil 112 at a predetermined pattern. Next, in order to make the front face of a photoresist layer 113 flat, it heat-treats at predetermined temperature. Next, the thin film coil 114 of the 2nd layer is formed on a photoresist layer 113. Next, a photoresist layer 115 is formed on a photoresist layer 113 and a coil 114 at a predetermined pattern. Next, in order to make the front face of a photoresist layer 115 flat, it heat-treats at predetermined temperature.

[0013] Next, as shown in drawing 17 , the up magnetic pole layer 116 which consists of a magnetic material for recording heads, for example, a permalloy, is formed on the up magnetic pole chip 110, a photoresist layer 113,115, and a magnetic layer 119. Next, the overcoat layer 117 which consists of an alumina is formed on the up magnetic pole layer 116. Finally, a slider is machined, the pneumatic bearing side 118 of a recording head and the reproducing head is formed, and the thin film magnetic head is completed.

[0014] In drawing 17 , TH expresses throat height and MR-H expresses MR height. In addition, throat height means the length (height) from the edge by the side of a pneumatic bearing side of the portion which two magnetic pole layers counter through a record gap layer to the edge of an opposite side. Moreover, MR height means the length (height) from the edge by the side of the pneumatic bearing side of MR element to the edge of an opposite side. Moreover, in drawing 17 , P2W express magnetic pole width of face, i.e., recording track width of face. There is an apex angle (Apex Angle) as shown by theta else [, such as throat height and MR height, ] in drawing 17 as a factor which determines the performance of the thin film magnetic head. This apex angle says the angle of the straight line which connects the corner of the side by the side of the magnetic pole in the coil portion (henceforth the apex section) which was covered by the photoresist layer 113,115 and rose in the shape of a mountain, and the upper surface of an insulating layer 111 to make.

[0015]

[Problem(s) to be Solved by the Invention] In order to raise the performance of the thin film magnetic head, it is important to form correctly the throat height TH as shown in drawing 17 , MR height MR-H, the apex angle theta, and recording track width-of-face P2W.

[0016] In order to enable high surface density record especially in recent years (i.e., in order to form the recording head of ** truck structure), the submicron size of 1.0 micrometers or less is demanded of width-of-recording-track P2W. Therefore, the technology of processing an up magnetic pole into a submicron size using semiconductor processing technology is needed.

[0017] Here, it poses a problem that it is difficult to form minutely the up magnetic pole layer formed on the apex section.

[0018] By the way, as a method of forming an up magnetic pole layer, as shown in JP,7-262519,A, the frame galvanizing method is used, for example. When forming an up magnetic pole

layer using the frame galvanizing method, on the whole, the thin electrode layer which consists of a permalloy is first formed by sputtering on the apex section. Next, on it, a photoresist is applied, patterning is carried out according to a photolithography process, and the frame for plating (outer frame) is formed. And an up magnetic pole layer is formed by the galvanizing method by using as a seed layer the electrode layer formed previously.
[0019] However, there is the difference of elevation 7-10 micrometers or more in the apex section and other portions, for example. On this apex section, a photoresist is applied by the thickness of 3-4 micrometers. Supposing the thickness of the photoresist on the apex section is at least 3-micrometer or more need, since the photoresist with a fluidity gathers in the lower one, in the lower part of the apex section, a photoresist film with a thickness of 8-10 micrometers or more will be formed, for example.
[0020] In order to realize recording track width of face of a submicron size as mentioned above, it is necessary to form the frame pattern of the width of face of a submicron size with a photoresist film. Therefore, you have to form a pattern with a detailed submicron size on the apex section with a photoresist film with the thickness of 8-10 micrometers or more. However, it was very difficult on the manufacturing process to form the photoresist pattern of such thick thickness by ** pattern width of face.
[0021] And at the time of exposure of a photolithography, the light for exposure reflects by the ground electrode layer as a seed layer, a photoresist exposes, collapse of a photoresist pattern etc. arises and a sharp and exact photoresist pattern is no longer obtained by this reflected light.

[0022] Thus, when magnetic pole width of face became a submicron size conventionally, there was a trouble that it became difficult to form an up magnetic layer with a sufficient precision.
[0023] As drawing 15 of the above-mentioned conventional example or the process of drawing 17 also showed, after forming the width of recording track 1.0 micrometers or less from such a thing with the up magnetic pole chip 110 effective in formation of the ** truck of a recording head, the method of forming the up magnetic pole layer 116 used as the yoke portion connected with this up magnetic pole chip 110 is also adopted (refer to JP,62-245509,A and JP,60-10409,A). Thus, it becomes possible by dividing the usual up magnetic pole layer into the up magnetic pole layer 116 used as the up magnetic pole chip 110 and a yoke portion to form minutely the up magnetic pole chip 110 which determines the width of recording track by submicron width of face on the flat field on the record gap layer 109.
[0024] However, also in such the thin film magnetic head, there were still the following troubles.
[0025] (1) First, by the conventional thin film magnetic head shown in drawing 17 , since the width of recording track of a recording head is prescribed by the up magnetic pole chip 110, it can be said that it is not necessary to process the up magnetic pole layer 116 into about 110 up magnetic pole chip minutely. Still, if the width of recording track of a recording head is set to microscopic **, especially 0.5 micrometers or less, also in the up magnetic pole layer 116, the process tolerance of submicron width of face will be required. However, in the conventional thin film magnetic head, the up magnetic pole layer 116 was difficult to form the up magnetic pole layer 116 minutely for the above-mentioned reason from being formed on the apex section. Moreover, since it needed to connect magnetically to the up magnetic pole chip 110 with narrow width of face, the up magnetic pole layer 116 needed to be formed in width of face larger than the up magnetic pole chip 110. From these reasons, the up magnetic pole layer 116 is formed in width of face larger than the up magnetic pole chip 110 by the conventional thin film magnetic head. Therefore, in the conventional thin film magnetic head, writing was performed by the up magnetic pole layer 116 side, and there was fault which originally writes data also in fields other than the field which should be recorded that the so-called side light was generated, to a record medium. In order that such fault may raise the performance of a recording head, when a coil is formed in two-layer or three layers, compared with the case where a coil is formed in one layer, the height of the apex section becomes high and it becomes more remarkable.
[0026] (2) Moreover, in the conventional magnetic head, throat height is determined in the edge of a side far from the pneumatic bearing side 118 of the up magnetic pole chip 110. However, if the width of face of this up magnetic pole chip 110 becomes narrow, in photo lithography, a

pattern edge will be roundish and will be formed. Therefore, the throat height of which a highly precise size is required became uneven, and the situation where the balance between the width of recording track of MR element was missing had occurred in processing of the pneumatic bearing side 118, and the polish process. For example, as the width of recording track, when 0.5-0.6 micrometers was required, the edge of a side far from the pneumatic bearing side 118 of the up magnetic pole chip 110 shifted from the throat height zero position (position of the edge by the side of the pneumatic bearing side of the insulating layer which determines throat height) to the pneumatic bearing side 118 side, the record gap opened greatly, and the problem of the writing of record data becoming impossible often occurred.
[0027] Reduction of the width of recording track of a recording head was difficult conventionally [ the trouble of the above (1) and (2) to ].
[0028] (3) In the further conventional thin film magnetic head, there was a trouble that it was difficult to shorten magnetic-path length (Yoke Length). That is, although the recording head which could realize the short head of magnetic-path length and was excellent in especially the RF property could be formed so that the coil pitch was small, when a coil pitch was made small infinite, the distance from a throat height zero position to the periphery edge of a coil had become the big factor which bars shortening magnetic-path length. Since magnetic-path length can do the two-layer coil short rather than the coil of one layer, he has adopted the two-layer coil in the recording head for many RFs. However, by the conventional magnetic head, after forming the coil of the 1st layer, in order to form the insulator layer between coils, the photoresist film is formed by the thickness of about 2 micrometers. Therefore, the small apex roundish [ wore ] is formed in the periphery edge of the coil of the 1st layer. Next, although the coil of a two-layer eye is formed on it, since etching of the seed layer of a coil cannot be performed but a coil short-circuits by the ramp of the apex section in that case, it is necessary to form the coil of a two-layer eye in a flat part.
[0029] When follow, for example, thickness of a coil is set to 2-3 micrometers, thickness of the insulator layer between coils is set to 2 micrometers and an apex angle is made into 45 degrees - 55 degrees, as magnetic-path length Double precision of the 4-5-micrometer distance which is the distance of a up to [ from the periphery edge of a coil ] near the throat height zero position in addition to the length of the portion corresponding to a coil (4-5 micrometers also of distance from the contact section of an up magnetic pole layer and a lower magnetic pole layer to a coil inner circumference edge are also required.) 8-10 micrometers is required. Length other than the portion corresponding to this coil had become the factor which bars reduction of magnetic-path length.
[0030] Here, the case where the 11-volume coil whose space the line breadth of a coil is 1.0 micrometers and is 1.0 micrometers is formed by two-layer is considered. In this case, as shown in drawing 17 , when it is made the 1st layer into six volumes and a two-layer eye is made into five volumes, the length of the portion corresponding to the coil 112 of the 1st layer is 11 micrometers among magnetic-path length. A length of a total of eight -10 micrometers is needed for magnetic-path length as a distance to the edge of the photoresist layer 113 for insulating the coil 112 of the 1st layer from the periphery edge and inner circumference edge of a coil 112 of the 1st layer. In addition, as the sign L0 showed magnetic-path length in drawing 17 , the length of the portion except the magnetic pole portion of the magnetic pole layers and the contact portion expresses with this application. Thus, conventionally, reduction of magnetic-path length is difficult and this had barred the improvement of a RF property.
[0031] By the way, in the thin film magnetic head shown in drawing 17 , the coil is wound in the shape of a whorl. on the other hand -- U.S. Pat. No. 5,703,740, JP,48-55718,A, JP,60-113310,A, and JP,63-201908,A -- a coil -- a center [ layer / magnetic pole ] -- carrying out -- being spiral (spiral) -- the wound thin film magnetic head is shown Thus, since the magnetomotive force generated with the coil can be efficiently told to a magnetic pole layer according to the structure which wound the coil spirally, compared with the structure which wound the coil in the shape of a whorl, the number of turns of a coil can be lessened, consequently it becomes reducible [ magnetic-path length ].
[0032] However, since the apex section can do a coil also in the conventional thin film magnetic

head of the structure wound spirally in this way, the trouble which still originates in the apex section as mentioned above remains.

[0033] this invention was made in view of this trouble, and the purpose is in offering the thin film magnetic head which enabled reduction of the width of recording track of an induction-type MAG sensing element, and reduction of magnetic-path length, and its manufacture method.

[0034]

[Means for Solving the Problem] The 1st and 2nd magnetic layers which consist of at least one layer including the magnetic pole portion which the part of the side which the thin film magnetic head of this invention is connected magnetically, and counters a record medium counters mutually through a record gap layer, respectively, A part passes through between the 1st and 2nd magnetic layers in the state where it insulated to the 1st and 2nd magnetic layers. It has the thin film coil spirally wound focusing on one [ at least ] magnetic layer. and the 1st magnetic layer It has the 1st portion which counters some thin film coils, and the 2nd portion which is connected to the field by the side of the 2nd magnetic layer in the 1st portion, and forms a magnetic pole portion, and some thin film coils are arranged in the side of the 2nd portion of the 1st magnetic layer.

[0035] The 1st and 2nd magnetic layers which consist of at least one layer including the magnetic pole portion which the part of the side which the manufacture method of the thin film magnetic head of this invention is connected magnetically, and counters a record medium counters mutually through a record gap layer, respectively, The process which a part is the manufacture method of the thin film magnetic head equipped with the thin film coil which passes through between the 1st and 2nd magnetic layers, and forms the 1st magnetic layer in the state where it insulated to the 1st and 2nd magnetic layers, In the process which forms a record gap layer on the 1st magnetic layer, the process which forms the 2nd magnetic layer on a record gap layer, and the state where it insulated to the 1st and 2nd magnetic layers So that a part may pass through between the 1st and 2nd magnetic layers and it may be spirally wound focusing on one [ at least ] magnetic layer The process which forms the 1st magnetic layer including the process which forms a thin film coil The process which forms the 1st portion which counters some thin film coils, and the 2nd portion which is connected to the field by the side of the 2nd magnetic layer in the 1st portion, and forms a magnetic pole portion, and forms a thin film coil A thin film coil is formed so that some thin film coils may be arranged in the side of the 2nd portion of the 1st magnetic layer.

[0036] the thin film magnetic head or its manufacture method of this invention -- a thin film coil -- a part -- between the 1st and 2nd magnetic layers -- passing -- and a center [ magnetic layer / one / at least ] / -- carrying out -- being spiral (spiral) -- it is prepared so that it may be wound Thereby, reduction of magnetic-path length is attained. Moreover, in this invention, the 1st magnetic layer has the 1st portion which counters some thin film coils, and the 2nd portion which is connected to the field by the side of the 2nd magnetic layer in the 1st portion, and forms a magnetic pole portion, and some thin film coils are arranged in the side of the 2nd portion of the 1st magnetic layer. This becomes possible to form the 2nd magnetic layer on a flat field, consequently reduction of the width of recording track of a recording head is attained.

[0037] Moreover, by the thin film magnetic head or its manufacture method of this invention, a thin film coil has the portion spirally wound focusing on the 2nd magnetic layer.

[0038] Moreover, by the thin film magnetic head or its manufacture method of this invention, the 2nd magnetic layer may have the magnetic pole partial layer which forms for example, a magnetic pole portion, and the yoke partial layer which is connected to this magnetic pole partial layer, and forms a yoke portion. In this case, a thin film coil may pass through the side of the 2nd portion of the 1st magnetic layer, and may have the 1st portion spirally wound focusing on the 2nd magnetic layer, and the 2nd portion which passed through the side of the magnetic pole partial layer of the 2nd magnetic layer, and was spirally wound focusing on the 2nd magnetic layer. Or a thin film coil may pass through the side of the 2nd portion of the 1st magnetic layer, and may have the 1st portion spirally wound focusing on the 1st magnetic layer, and the 2nd portion which passed through the side of the magnetic pole partial layer of the 2nd magnetic layer, and was spirally wound focusing on the 2nd magnetic layer. Moreover, you may arrange the end face

of the side which counters the record medium of the yoke partial layer of the 2nd magnetic layer in the position distant from the field which counters the record medium of the thin film magnetic head.

[0039] Moreover, by the thin film magnetic head or its manufacture method of this invention, the 2nd portion of the 1st magnetic layer specifies throat height, and you may make it the 2nd magnetic layer specify recording track width of face by it.

[0040] Moreover, by the thin film magnetic head or its manufacture method of this invention, some thin film coils arranged in the side of the 2nd portion of the 1st magnetic layer may be covered further, and the insulating layer to which flattening of the field by the side of a record gap layer was carried out may be prepared.

[0041] Moreover, by the thin film magnetic head or its manufacture method of this invention, it is arranged so that a magnetic resistance element and the part of the side which counters a record medium may counter on both sides of a magnetic resistance element further, and you may prepare the 1st for shielding a magnetic resistance element, and the 2nd shield layer. In this case, the 1st magnetic layer may serve as the 2nd shield layer.

[0042]

[Embodiments of the Invention] Hereafter, the gestalt of operation of this invention is explained in detail with reference to a drawing.

[the gestalt of the 1st operation] -- with reference to drawing 1 or drawing 7 , the thin film magnetic head concerning the gestalt of operation of the 1st of this invention and its manufacture method are explained first In addition, in drawing 1 or drawing 6 , (a) shows a cross section perpendicular to a pneumatic bearing side, and (b) shows the cross section parallel to the pneumatic bearing side of a magnetic pole portion.

[0043] By the manufacture method of the thin film magnetic head concerning the gestalt of this operation, first, as shown in drawing 1 , the insulating layer 2 which consists of an alumina (aluminum 2O3) is deposited by the thickness of about 5 micrometers on the substrate 1 which consists of ARUTIKKU (aluminum 2O3, TiC). Next, the lower shield layer 3 for the reproducing heads which consists of a magnetic material, for example, a permalloy, is formed on an insulating layer 2 at the thickness of about 3 micrometers. The lower shield layer 3 uses for example, a photoresist film as a mask, and forms it alternatively on an insulating layer 2 by the galvanizing method. Next, it grinds until it forms in the thickness of 4-6 micrometers the insulating layer 20 which consists of an alumina, for example, the lower shield layer 3 is exposed to the whole with CMP (chemical machinery polish), and flattening processing of the front face is carried out.

[0044] Next, as shown in drawing 2 , on the lower shield layer 3, the spatter deposition of an alumina or the CHITSU-ized aluminum is carried out, and the lower shield gap film 4 as an insulating layer is formed. Next, the MR element 5 for reproduction is formed on the lower shield gap film 4 at the thickness of dozens of nm. The MR element 5 forms MR film formed by the spatter by ***********ing alternatively. In addition, the element using the magnetosensitive film in which the magnetoresistance effects, such as the AMR element, a GMR element, or a TMR (tunnel magnetoresistance effect) element, are shown can be used for the MR element 5. Next, the electrode layer 6 of the couple electrically connected to the MR element 5 is formed on the lower shield gap film 4 at the thickness of dozens of nm. Next, the up shield gap film 7 as an insulating layer is formed on the lower shield gap film 4 and the MR element 5, and the MR element 5 is laid underground in the shield gap film 4 and 7.

[0045] Next, on the up shield gap film 7, it consists of a magnetic material and 1st partial 8a of the lower [ an up shield layer-cum-] magnetic pole layer (it is hereafter described as a lower magnetic pole layer.) used to the both sides of the reproducing head and a recording head is alternatively formed by the thickness of about 1.0-2.0 micrometers. 1st partial 8a of a lower magnetic pole layer counters some thin film coils mentioned later.

[0046] Next, the insulating layer 9 which consists of an alumina is formed in the whole at the thickness of about 3-4 micrometers. Next, for example by CMP, an insulating layer 9 is ground and flattening processing of the front face is carried out until 1st partial 8a of a lower magnetic pole layer is exposed.

[0047] Next, as shown in drawing 3 , the 2nd partial 8b of a lower magnetic pole layer and 3rd

partial 8c are formed on 1st partial 8a of a lower magnetic pole layer at the thickness of about 1.5-2.5 micrometers. 2nd partial 8b forms the magnetic pole portion of a lower magnetic pole layer, and is connected to the field by the side of the up magnetic pole layer of 1st partial 8a. 3rd partial 8c is a portion for connecting 1st partial 8a and an up magnetic pole layer. In the gestalt of this operation, the position of the edge of an opposite side (it sets to drawing and is right-hand side) specifies throat height in the pneumatic bearing side 30 of 2nd partial 8b. That is, this position turns into a throat height zero position which is a position of the edge of an opposite side in the pneumatic bearing side 30 of a magnetic pole portion.

[0048] The 2nd partial 8b of a lower magnetic pole layer and 3rd partial 8c NiFe (nickel:80 % of the weight, Fe:20 % of the weight), NiFe (nickel:45 % of the weight, Fe:55 % of the weight) which is high saturation-magnetic-flux-density material are used. It may form in a predetermined pattern by the galvanizing method, and using material, such as FeN, FeZrN, etc. which are high saturation-magnetic-flux-density material, after a spatter, it **********s alternatively and you may form in a predetermined pattern by ion milling etc. In addition, you may use CoFe, Co system amorphous material, etc. which are high saturation-magnetic-flux-density material.

[0049] Next, the insulator layer 10 which consists of an alumina is formed in the whole at the thickness of about 0.3-0.6 micrometers.

[0050] Next, although not illustrated, the seed layer for forming the 1st layer portion of a thin film coil by the galvanizing method on an insulator layer 10 is formed by the spatter. Next, on it, a photoresist is applied, patterning is carried out according to a photolithography process, and the frame 11 for plating is formed.

[0051] Next, 1st layer partial 12a of the thin film coil which consists of copper (Cu) by the frame galvanizing method is formed in the thickness of about 1.0-2.0 micrometers using a frame 11. 1st layer partial 12a of a thin film coil is arranged in the side of 2nd partial 8b of a lower magnetic pole layer. Moreover, 1st layer partial 12a of a thin film coil consists of a portion of the shape of two or more square pole prolonged in the direction which intersects the space in drawing 3 (a).

[0052] Next, as shown in drawing 4 , after removing a frame 11 and the seed layer under it, the insulating layer 13 which consists of an alumina is formed in the whole at the thickness of about 3-4 micrometers. Next, for example by CMP, an insulating layer 13 is ground and flattening processing of the front face is carried out until 2nd partial 8b of a lower magnetic pole layer and 3rd partial 8c are exposed. Although it has not exposed, you may make it 1st layer partial 12a expose 1st layer partial 12a of a thin film coil by drawing 4 here.

[0053] Next, as shown in drawing 5 , the record gap layer 14 which consists of an insulating material is formed at the thickness of 0.2-0.3 micrometers on 2nd partial 8b of a lower magnetic pole layer, the 3rd partial 8c, and an insulating layer 13. Generally as an insulating material used for the record gap layer 14, there are an alumina, alumimium nitride, silicon oxide system material, silicon nitride system material, diamond-like carbon (DLC), etc.

[0054] Next, for magnetic-path formation, on 3rd partial 8c of a lower magnetic pole layer, the record gap layer 14 is **********ed partially and a contact hole is formed.

[0055] Next, the up magnetic pole layer 15 is formed on the record gap layer 14 at the thickness of about 2.0-3.0 micrometers. Using NiFe (nickel:80 % of the weight, Fe:20 % of the weight), NiFe (nickel:45 % of the weight, Fe:55 % of the weight) which is high saturation-magnetic-flux-density material, the up magnetic pole layer 15 may be formed in a predetermined pattern by the galvanizing method, using material, such as FeN, FeZrN, etc. which are high saturation-magnetic-flux-density material, **********s alternatively and may be formed in a predetermined pattern by ion milling etc. after a spatter. In addition, you may use CoFe, Co system amorphous material, etc. which are high saturation-magnetic-flux-density material. Moreover, it is good also as structure which laid the insulator layer of an inorganic system, and magnetic layers, such as a permalloy, on top of many layers for the up magnetic pole layer 15 because of an improvement of a RF property.

[0056] Next, the record gap layer 14 is alternatively **********ed by dry etching by using the up magnetic pole layer 15 as a mask. Reactive ion etching (RIE) which used gas, such as chlorine-based gas of BCl2 and Cl2 grade and fluorine system gas of CF4 and SF6 grade, is used for the dry etching at this time. Next, it considers as trim structure as **********s about about

0.3-0.6 micrometers alternatively and showed 2nd partial 8b of a lower magnetic pole layer to drawing 5 (b), for example by argon ion milling. According to this trim structure, the increase in the effective width of recording track by the breadth of the magnetic flux generated at the time of the writing of a ** truck can be prevented.
[0057] Next, the insulator layer 16 which consists of an alumina is formed in the whole at the thickness of about 0.3-0.9 micrometers.
[0058] Next, although not illustrated, in the portion of the both-ends top in the each [ 4] -sided prism portion of 1st layer partial 12a of a thin film coil, a contact hole which penetrates an insulator layer 16, the record gap layer 14, and an insulating layer 13, and reaches 1st layer partial 12a of a thin film coil by reactive ion etching or ion milling is formed.
[0059] Next, 2nd layer partial 12b of the thin film coil which consists of copper (Cu) is formed by the frame galvanizing method at the thickness of about 1.0-2.0 micrometers on the insulator layer 16 located on the up magnetic pole layer 15. 2nd layer partial 12b of a thin film coil consists of a portion of the shape of two or more square pole prolonged in the direction which intersects perpendicularly with the space in drawing 5 (a). The both ends in the each [ 4] -sided prism portion of 2nd layer partial 12b of this thin film coil are connected to the both ends in the each [ 4] -sided prism portion of 1st layer partial 12a of a thin film coil through the connection section which it fills up with the material of a thin film coil, and is formed in the above-mentioned contact hole.
[0060] Next, as shown in drawing 6 , the overcoat layer 17 which consists of an alumina is formed in the thickness of 20-40 micrometers, flattening of the front face is carried out to the whole, and the pad for electrodes which is not illustrated is formed on it. Finally, polish processing of a slider is performed, the pneumatic bearing side 30 of a recording head and the reproducing head is formed, and the thin film magnetic head concerning the gestalt of this operation is completed.
[0061] With the gestalt of this operation, the lower magnetic pole layer which consists of the 1st partial 8a, the 2nd partial 8b, and the 3rd partial 8c is equivalent to the 1st magnetic layer in this invention, and the up magnetic pole layer 15 is equivalent to the 2nd magnetic layer in this invention. Moreover, the lower shield layer 3 is equivalent to the 1st shield layer in this invention. Moreover, since the lower magnetic pole layer serves as the up shield layer, it is equivalent also to the 2nd shield layer in this invention.
[0062] Drawing 7 is the plan of the thin film magnetic head concerning the gestalt of this operation. In addition, in this drawing, the overcoat layer 17, other insulating layers, and the insulator layer are omitted. In addition, in drawing 7 , among drawing, in order that sign 8B may consider as trim structure, 2nd partial 8b of a lower magnetic pole layer expresses the portion into which it **********s.
[0063] As shown in drawing 7 , the up magnetic pole layer 15 has yoke partial 15B connected with magnetic pole partial 15A while being arranged to the field which counters magnetic pole partial 15A arranged in the position which counters 2nd partial 8b of a lower magnetic pole layer through the record gap layer 14, and 1st layer partial 12a of a thin film coil. The position of the connection section of magnetic pole partial 15A and yoke partial 15B is the throat height zero position TH0 or the position of the near. Magnetic pole partial 15A has narrow fixed width of face. The width of face of this magnetic pole partial 15A specifies the width of recording track of a recording head.
[0064] Moreover, in drawing 7 , the sign 12 expresses the thin film coil containing 1st layer partial 12a, 2nd layer partial 12b, and connection section 12c that connects these. 1st layer partial 12a of the thin film coil 12 and 2nd layer partial 12b are connected with the JIGUZAKU form through connection section 12c. Thereby, the thin film coil 12 is spirally wound focusing on yoke partial 15B of the up magnetic pole layer 15.
[0065] As explained above, the thin film magnetic head concerning the form of this operation is equipped with the reproducing head and the recording head (induction-type MAG sensing element). The reproducing head is arranged so that the MR element 5 and the part of the side which counters a record medium may counter on both sides of the MR element 5, and it has the lower shield layer 3 and up shield layer (lower magnetic pole layer) for shielding the MR element

5.
[0066] The lower magnetic pole layer (8a-8c) and the up magnetic pole layer 15 which consist of at least one layer including the magnetic pole portion which the part of the side which a recording head is connected magnetically and counters a record medium counters mutually through the record gap layer 14, respectively, It has the thin film coil 12 which the part passed through between a lower magnetic pole layer and the up magnetic pole layers 15, and was spirally wound focusing on the up magnetic pole layer 15 in the state where it insulated to these.

[0067] 1st partial 8a to which a lower magnetic pole layer counters 1st layer partial 12a of a thin film coil with the form of this operation, It connects with the field by the side of the up magnetic pole layer 15 in this 1st partial 8a, and has 2nd partial 8b which forms a magnetic pole portion, and 1st layer partial 12a of the thin film coil 12 is arranged in the side of 2nd partial 8b of a lower magnetic pole layer.
[0068] According to the gestalt of this operation, since the thin film coil 12 was spirally wound focusing on the up magnetic pole layer 15, the magnetomotive force generated with the thin film coil 12 can be efficiently told to the up magnetic pole layer 15. Therefore, compared with the structure which wound the thin film coil in the shape of a whorl, the number of turns of the thin film coil 12 can be lessened.
[0069] Furthermore, with the form of this operation, it is on 1st partial 8a of a lower magnetic pole layer, 1st layer partial 12a of the thin film coil 12 is arranged to the side of 2nd partial 8b, flattening of the upper surface of the wrap insulating layer 13 is carried out for 1st layer partial 12a of the thin film coil 12, and the up magnetic pole layer 15 is formed on a flat field. Therefore, the both sides of 1st layer partial 12a of the thin film coil 12 and 2nd layer partial 12b can be formed on a flat field. Thereby, it becomes possible to form the thin film coil 12 minutely.
[0070] Furthermore, according to the form of this operation, since the apex section does not exist, the edge of the thin film coil 12 can be arranged near the throat height zero position TH0.
[0071] According to the form of this operation from these things, for example compared with the former, it becomes about 30 - 50% or less reducible [ magnetic-path length ]. Furthermore, it can prevent that the magnetomotive force generated with the thin film coil 12 is saturated on the way, and the magnetomotive force generated with the thin film coil 12 can be efficiently used for record. Therefore, according to the form of this operation, it becomes possible to offer the thin film magnetic head which was excellent in the over-writing property which are the RF property of a recording head, a nonlinear transition shift (it is described as NLTS below Non-linear Transition Shift;.), and a property in the case of carrying out overwrite.
[0072] Moreover, since according to the form of this operation it is on 1st partial 8a of a lower magnetic pole layer, 1st layer partial 12a of the thin film coil 12 is arranged to the side of 2nd partial 8b and flattening of the upper surface of the wrap insulating layer 13 was carried out for 1st layer partial 12a of the thin film coil 12, the up magnetic pole layer 15 which specifies the width of recording track of a recording head can be formed on a flat field. Therefore, according to the form of this operation, about magnetic pole partial 15A of the up magnetic pole layer 15, formation becomes possible minutely and it also becomes for example, a half micron size and a quarter micron size reducible [ the width of recording track of a recording head ]. The thin film magnetic head which has by this the field recording density of the 20-30 gigabit / (inch) 2 demanded from now on also becomes realizable.
[0073] Moreover, with the form of this operation, the up magnetic pole layer 15 which specifies the width of recording track of a recording head does not specify throat height, but 2nd partial 8b of a lower magnetic pole layer specifies throat height with it. Therefore, according to the form of this operation, even if the width of recording track becomes small, it becomes possible to be accurate and to specify throat height uniformly.
[0074] Moreover, with the form of this operation, since the wrap insulating layer 13 was formed for 1st layer partial 12a of the thin film coil 12 arranged in the side of 2nd partial 8b of a lower magnetic pole layer and flattening of the upper surface of this insulating layer 13 was carried out, formation of 2nd layer partial 12b of the record gap layer 14 formed after that, the up magnetic pole layer 15, and the thin film coil 12 etc. becomes easy.

[0075] Moreover, with the form of this operation, since the insulator layer 10 which consists of inorganic material from which thin and sufficient isolation voltage is obtained is formed between a lower magnetic pole layer and 1st layer partial 12a of the thin film coil 12, big isolation voltage can be obtained between a lower magnetic pole layer and 1st layer partial 12a of the thin film coil 12.

[0076] Moreover, in the form of this operation, as shown in drawing 7 , the up magnetic pole layer 15 has fixed width of face of 3 micrometers or more in the portion of an opposite side in the pneumatic bearing side 30, for example rather than the throat height zero position TH0 or the position of the near, and has width of face with fixed half micron size and quarter micron size in the portion by the side of the pneumatic bearing side 30 rather than the throat height zero position TH0 or the position of the near. Therefore, the magnetic flux which passes the up magnetic pole layer 15 is not saturated with the portion of an opposite side in the pneumatic bearing side 30 rather than the throat height zero position TH0 or the position of the near, but is saturated in the portion by the side of the pneumatic bearing side 30 rather than the throat height zero position TH0 or the position of the near. Thereby, NLTS and an over-writing property can be raised.

[0077] With reference to [the form of the 2nd operation] next drawing 8 , or drawing 10 , the thin film magnetic head concerning the form of operation of the 2nd of this invention and its manufacture method are explained. In addition, in drawing 8 and drawing 9 , (a) shows a cross section perpendicular to a pneumatic bearing side, and (b) shows the cross section parallel to the pneumatic bearing side of a magnetic pole portion.

[0078] As for the thin film magnetic head concerning the form of this operation, a thin film coil is spirally wound doubly focusing on an up magnetic pole layer. With the form of this operation, an outside portion is called 1st portion among this thin film coil, and an inside portion is called 2nd portion. In addition, the 1st portion and 2nd portion of a thin film coil are formed by each with copper.

[0079] The process which forms an insulator layer 10 by the manufacture method of the thin film magnetic head concerning the form of this operation is the same as the form of the 1st operation. As shown in drawing 8 , with the form of this operation, 1st layer partial 21a of the 1st portion of a thin film coil is formed by the frame galvanizing method on an insulator layer 10 after that at the thickness of about 1.0-2.0 micrometers. 1st layer partial 21a of the 1st portion of a thin film coil is arranged in the side of 2nd partial 8b of a lower magnetic pole layer. Moreover, 1st layer partial 21a of the 1st portion of a thin film coil consists of a portion of the shape of two or more square pole prolonged in the direction which intersects the space in drawing 8 (a).

[0080] Next, the insulating layer 13 which consists of an alumina is formed in the whole at the thickness of about 3-4 micrometers. Next, for example by CMP, an insulating layer 13 is ground and flattening processing of the front face is carried out until 2nd partial 8b of a lower magnetic pole layer and 3rd partial 8c are exposed. Although it has not exposed, you may make it 1st layer partial 21a expose 1st layer partial 21a of the 1st portion of a thin film coil by drawing 8 here.

[0081] Next, the record gap layer 14 is formed at the thickness of 0.2-0.3 micrometers on 2nd partial 8b of a lower magnetic pole layer, the 3rd partial 8c, and an insulating layer 13. Next, on 3rd partial 8c of a lower magnetic pole layer, the record gap layer 14 is **********ed partially and a contact hole is formed.

[0082] Next, while forming in the thickness of 1.0-3.0 micrometers magnetic pole partial layer 15a which forms the magnetic pole portion of an up magnetic pole layer on the record gap layer 14, magnetic layer 15b is formed in the position of the contact hole formed on 3rd partial 8c of a lower magnetic pole layer at the thickness of 1.0-3.0 micrometers. Magnetic layer 15b is a portion for connecting the yoke partial layer of an up magnetic pole layer and lower magnetic pole layer which are mentioned later. With the form of this operation, the length of magnetic pole partial layer 15a of an up magnetic pole layer is formed more than the length of 2nd partial 8b of a lower magnetic pole layer.

[0083] Using NiFe (nickel:80 % of the weight, Fe:20 % of the weight), NiFe (nickel:45 % of the weight, Fe:55 % of the weight) which is high saturation-magnetic-flux-density material, magnetic pole partial layer 15a and magnetic layer 15b of an up magnetic pole layer may be formed in a

predetermined pattern by the galvanizing method, using material, such as FeN, FeZrN, etc. which are high saturation-magnetic-flux-density material, ********** alternatively and may be formed in a predetermined pattern by ion milling etc. after a spatter. In addition, you may use CoFe, Co system amorphous material, etc. which are high saturation-magnetic-flux-density material.
[0084] Next, it considers as trim structure as **********ed the record gap layer 14 alternatively by dry etching by using magnetic pole partial layer 15a of an up magnetic pole layer as a mask, next **********s about about 0.3-0.6 micrometers alternatively and showed 2nd partial 8b of a lower magnetic pole layer to drawing 8 (b) for example, by argon ion milling.
[0085] Next, the insulator layer 22 which consists of an alumina is formed in the coil formation field on the record gap layer 14 at the thickness of about 0.3-0.6 micrometers.
[0086] Next, 1st layer partial 23a of the 2nd portion of a thin film coil is formed in the thickness of about 1.0-2.0 micrometers by the frame galvanizing method. 1st layer partial 23a of the 2nd portion of a thin film coil is arranged in the side of magnetic pole partial layer 15a of an up magnetic pole layer. Moreover, 1st layer partial 23a of the 2nd portion of a thin film coil consists of a portion of the shape of two or more square pole prolonged in the direction which intersects the space in drawing 8 (a).
[0087] Next, the insulating layer 24 which consists of an alumina is formed in the whole at the thickness of about 3-4 micrometers. Next, for example by CMP, an insulating layer 24 is ground and flattening processing of the front face is carried out until magnetic pole partial layer 15a and magnetic layer 15b of an up magnetic pole layer are exposed.
[0088] Next, as shown in drawing 9 , magnetic pole partial layer 15a of an up magnetic pole layer and magnetic layer 15b by which flattening was carried out, and yoke partial layer 15c which forms the yoke portion of an up magnetic pole layer on an insulating layer 24 are formed in the thickness of about 2-4 micrometers. Through magnetic layer 15b, this yoke partial layer 15c contacted 3rd partial 8c of a lower magnetic pole layer, and is connected magnetically. Using NiFe (nickel:80 % of the weight, Fe:20 % of the weight), NiFe (nickel:45 % of the weight, Fe:55 % of the weight) which is high saturation-magnetic-flux-density material, yoke partial layer 15c of an up magnetic pole layer may be formed in a predetermined pattern by the galvanizing method, using material, such as FeN, FeZrN, etc. which are high saturation-magnetic-flux-density material, **********s alternatively and may be formed in a predetermined pattern by ion milling etc. after a spatter. In addition, you may use CoFe, Co system amorphous material, etc. which are high saturation-magnetic-flux-density material. Moreover, it is good also as structure which laid the insulator layer of an inorganic system, and magnetic layers, such as a permalloy, on top of many layers for the up magnetic pole layer 15 because of an improvement of a RF property.
[0089] With the gestalt of this operation, the end face of the side (pneumatic bearing side 30 side) which counters the record medium of yoke partial layer 15c of an up magnetic pole layer is arranged in the position (it sets to drawing and is right-hand side) distant from the field which counters the record medium of the thin film magnetic head.
[0090] Next, the insulator layer 25 which consists of an alumina is formed in the whole at the thickness of about 0.3-0.9 micrometers.
[0091] Next, although not illustrated, in the portion of the both-ends top in the each [ 4] -sided prism portion of 1st layer partial 23a of the 2nd portion of a thin film coil, a contact hole which penetrates an insulator layer 25 and an insulating layer 24, and reaches 1st layer partial 23a of the 2nd portion of a thin film coil by reactive ion etching or ion milling is formed.
[0092] Next, 2nd layer partial 23b of the 2nd portion of a thin film coil is formed by the frame galvanizing method at the thickness of about 1.0-2.0 micrometers on the insulator layer 25 located on yoke partial layer 15c of an up magnetic pole layer. 2nd layer partial 23b of the 2nd portion of a thin film coil consists of a portion of the shape of two or more square pole prolonged in the direction which intersects perpendicularly with the space in drawing 9 (a). The both ends in the each [ 4] -sided prism portion of 2nd layer partial 23b of the 2nd portion of this thin film coil are connected to the both ends in the each [ 4] -sided prism portion of 1st layer partial 23a of the 2nd portion of a thin film coil through the connection section which it fills up with the material of a thin film coil, and is formed in the above-mentioned contact hole.
[0093] Next, the insulating layer 26 which consists of an alumina is formed in the thickness of

about 6-8 micrometers, and flattening of the front face is carried out to the whole.
[0094] Next, although not illustrated, in the portion of the both-ends top in the each [ 4] -sided prism portion of 1st layer partial 21a of the 1st portion of a thin film coil, a contact hole which penetrates an insulator layer 26, an insulator layer 25, the record gap layer 14, and an insulating layer 13, and reaches 1st layer partial 21a of the 1st portion of a thin film coil by reactive ion etching or ion milling is formed.
[0095] Next, 2nd layer partial 21b of the 1st portion of a thin film coil is formed by the frame galvanizing method on an insulating layer 26 at the thickness of about 1.0-2.0 micrometers. 2nd layer partial 21b of the 1st portion of a thin film coil consists of a portion of the shape of two or more square pole prolonged in the direction which intersects perpendicularly with the space in drawing 9 (a). The both ends in the each [ 4] -sided prism portion of 2nd layer partial 21b of the 1st portion of this thin film coil are connected to the both ends in the each [ 4] -sided prism portion of 1st layer partial 21a of the 1st portion of a thin film coil through the connection section which it fills up with the material of a thin film coil, and is formed in the above-mentioned contact hole.
[0096] Next, the overcoat layer 17 which consists of an alumina is formed in the thickness of 20-40 micrometers, flattening of the front face is carried out to the whole, and the pad for electrodes which is not illustrated is formed on it. Finally, polish processing of a slider is performed, the pneumatic bearing side 30 of a recording head and the reproducing head is formed, and the thin film magnetic head concerning the gestalt of this operation is completed.
[0097] With the gestalt of this operation, the up magnetic pole layer which consists of magnetic pole partial layer 15a, magnetic layer 15b, and yoke partial layer 15c is equivalent to the 2nd magnetic layer in this invention.
[0098] Drawing 10 is the plan of the thin film magnetic head concerning the gestalt of this operation. In this drawing, an overcoat layer, other insulating layers, and the insulator layer are omitted. In this drawing, the sign 21 expresses the 1st portion of the thin film coil containing 1st layer partial 21a, 2nd layer partial 21b, and connection section 21c that connects these. Moreover, the sign 23 expresses the 2nd portion of the thin film coil containing 1st layer partial 23a, 2nd layer partial 23b, and connection section 23c that connects these. 1st layer partial 21a of the 1st portion 21 of a thin film coil and 2nd layer partial 21b are connected with the JIGUZAKU form through connection section 21c. Thereby, the 1st portion 21 of a thin film coil is spirally wound focusing on yoke partial layer 15c of an up magnetic pole layer. Similarly, 1st layer partial 23a of the 2nd portion 23 of a thin film coil and 2nd layer partial 23b are connected with the JIGUZAKU form through connection section 23c. Thereby, the 2nd portion 23 of a thin film coil is spirally wound focusing on yoke partial layer 15c of an up magnetic pole layer.
[0099] Moreover, the 1st portion 21 and 2nd portion 23 of a thin film coil are connected by the connection section 29. It fills up with the material of a thin film coil, and the connection section 29 is formed in a contact hole which penetrates an insulator layer 25, the record gap layer 14, and an insulating layer 13, and reaches 1st layer partial 21a of the 1st portion 21 of a thin film coil.
[0100] As shown in drawing 9 , 1st layer partial 21a of the 1st portion 21 of a thin film coil passes through the side of 2nd partial 8b of a lower magnetic pole layer. Moreover, 1st layer partial 23a of the 2nd portion 23 of a thin film coil passes through the side of magnetic pole partial layer 15a of an up magnetic pole layer.
[0101] Since the thin film coils 21 and 23 doubly wound focusing on the up magnetic pole layer were formed according to the gestalt of this operation, compared with the gestalt of the 1st operation, magnetomotive force of a thin film coil can be enlarged and NLTS and an over-writing property can be raised more.
[0102] Moreover, since according to the gestalt of this operation 1st layer partial 21a of the 1st portion 21 of a thin film coil is arranged to the side of 2nd partial 8b of a lower magnetic pole layer and flattening of the upper surface of the wrap insulating layer 13 was carried out for this 1st layer partial 21a, magnetic pole partial layer 15a of an up magnetic pole layer can be formed on a flat field. Therefore, according to the gestalt of this operation, about magnetic pole partial layer 15a, formation becomes possible minutely and it also becomes for example, a half micron

size and a quarter micron size reducible [ the width of recording track of a recording head ].
[0103] Moreover, although the thin film coils 21 and 23 wound doubly are formed with the gestalt of this operation While arranging 1st layer partial 21a of the 1st portion 21 of a thin film coil to the side of 2nd partial 8b of a lower magnetic pole layer Since 1st layer partial 23a of the 2nd portion 23 of a thin film coil has been arranged to the side of magnetic pole partial layer 15a of an up magnetic pole layer, yoke partial layer 15c of an up magnetic pole layer can be formed on a flat field. Therefore, according to the gestalt of this operation, formation also of yoke partial layer 15c is attained minutely, and it becomes possible [ preventing generating of the so-called side light ].
[0104] Moreover, with the gestalt of this operation, the end face by the side of the pneumatic bearing side 30 of yoke partial layer 15c of an up magnetic pole layer is arranged in the position distant from the pneumatic bearing side 30 of the thin film magnetic head. Therefore, even when throat height is small, yoke partial layer 15c of an up magnetic pole layer cannot be exposed to the pneumatic bearing side 30, consequently generating of a side light can be prevented.
[0105] The composition of others in the gestalt of this operation, the operation, and the effect are the same as the gestalt of the 1st operation.
[0106] With reference to [the gestalt of the 3rd operation] next drawing 11 , or drawing 13 , the thin film mind head concerning the gestalt of operation of the 3rd of this invention and its manufacture method are explained. In addition, in drawing 11 and drawing 12 , (a) shows a cross section perpendicular to a pneumatic bearing side, and (b) shows the cross section parallel to the pneumatic bearing side of a magnetic pole portion.
[0107] The thin film magnetic head concerning the gestalt of this operation has the 1st portion around which the thin film coil was spirally wound focusing on the lower magnetic pole layer, and the 2nd portion spirally wound focusing on the up magnetic pole layer. In addition, the 1st portion and 2nd portion of a thin film coil are formed by each with copper.
[0108] The process which forms the lower shield gap film 4, the MR element 5, and the up shield gap film 7 by the manufacture method of the thin film magnetic head concerning the gestalt of this operation is the same as the gestalt of the 1st operation. As shown in drawing 11 , with the gestalt of this operation, 8d of magnetic layers which consist of a magnetic material is formed after that at the thickness of about 1-2 micrometers on the up shield gap film 7 located on the MR element 5. 8d of this magnetic layer makes a part of lower shield layer. Next, for example by reactive ion etching or ion milling, while ***********ing the shield gap films 4 and 7 in the field which forms a thin film coil, about 1-2 micrometers **********s the lower shield layer 3, for example, and a crevice is formed.
[0109] Next, the insulator layer 31 which consists of an alumina is formed in the whole at the thickness of about 0.3-0.6 micrometers. Next, 1st layer partial 32a of the 1st portion of a thin film coil is formed by the frame galvanizing method on an insulator layer 31 at the thickness of about 1.0-2.0 micrometers. 1st layer partial 32a of the 1st portion of a thin film coil consists of a portion of the shape of two or more square pole prolonged in the direction which intersects the space in drawing 11 (a).
[0110] Next, the insulating layer 33 which consists of an alumina is formed in the whole at the thickness of about 3-4 micrometers. Next, for example by CMP, an insulating layer 33 is ground and flattening processing of the front face is carried out until 8d of magnetic layers is exposed.
[0111] Next, as shown in drawing 12 , 1st partial 8a of a lower magnetic pole layer is alternatively formed by the thickness of about 1.0-2.0 micrometers on 8d of magnetic layers, and an insulating layer 33. Next, the insulating layer 9 which consists of an alumina is formed in the whole at the thickness of about 3-4 micrometers. Next, for example by CMP, an insulating layer 9 is ground and flattening processing of the front face is carried out until 1st partial 8a of a lower magnetic pole layer is exposed.
[0112] Next, the 2nd partial 8b of a lower magnetic pole layer and 3rd partial 8c are formed on 1st partial 8a of a lower magnetic pole layer at the thickness of about 1.5-2.5 micrometers. Next, the insulator layer 10 which consists of an alumina is formed in the whole at the thickness of about 0.3-0.6 micrometers.
[0113] Next, although not illustrated, in the portion of the both-ends top in the each [ 4] -sided

prism portion of 1st layer partial 32a of the 1st portion of a thin film coil, a contact hole which penetrates an insulator layer 10 and an insulating layer 33, and reaches 1st layer partial 32a of the 1st portion of a thin film coil by reactive ion etching or ion milling is formed.
[0114] Next, 2nd layer partial 32b of the 1st portion of a thin film coil is formed by the frame galvanizing method on an insulator layer 10 at the thickness of about 1.0-2.0 micrometers. 2nd layer partial 32b of the 1st portion of a thin film coil is arranged in the side of 2nd partial 8b of a lower magnetic pole layer. Moreover, 2nd layer partial 32b of the 1st portion of a thin film coil consists of a portion of the shape of two or more square pole prolonged in the direction which intersects perpendicularly with the space in drawing 12 (a). The both ends in the each [ 4] -sided prism portion of 2nd layer partial 32b of the 1st portion of this thin film coil are connected to the both ends in the each [ 4] -sided prism portion of 1st layer partial 32a of the 1st portion of a thin film coil through the connection section which it fills up with the material of a thin film coil, and is formed in the above-mentioned contact hole.
[0115] Next, the insulating layer 13 which consists of an alumina is formed in the whole at the thickness of about 3-4 micrometers. Next, for example by CMP, an insulating layer 13 is ground and flattening processing of the front face is carried out until 2nd partial 8b of a lower magnetic pole layer and 3rd partial 8c are exposed. Although it has not exposed, you may make it 2nd layer partial 32b expose 2nd layer partial 32b of the 1st portion of a thin film coil by drawing 12 here.
[0116] Next, the record gap layer 14 is formed at the thickness of 0.2-0.3 micrometers on 2nd partial 8b of a lower magnetic pole layer, the 3rd partial 8c, and an insulating layer 13. Next, on 3rd partial 8c of a lower magnetic pole layer, the record gap layer 14 is **********ed partially and a contact hole is formed.
[0117] Next, while forming in the thickness of 1.0-3.0 micrometers magnetic pole partial layer 15a which forms the magnetic pole portion of an up magnetic pole layer on the record gap layer 14, magnetic layer 15b is formed in the position of the contact hole formed on 3rd partial 8c of a lower magnetic pole layer at the thickness of 1.0-3.0 micrometers.
[0118] Next, it considers as trim structure as **********ed the record gap layer 14 alternatively by dry etching by using magnetic pole partial layer 15a of an up magnetic pole layer as a mask, next **********s about about 0.3-0.6 micrometers alternatively and showed 2nd partial 8b of a lower magnetic pole layer to drawing 12 (b) for example, by argon ion milling.
[0119] Next, the insulator layer 22 which consists of an alumina is formed in the coil formation field on the record gap layer 14 at the thickness of about 0.3-0.6 micrometers. Next, 1st layer partial 34a of the 2nd portion of a thin film coil is formed in the thickness of about 1.0-2.0 micrometers by the frame galvanizing method. 1st layer partial 34a of the 2nd portion of a thin film coil is arranged in the side of magnetic pole partial layer 15a of an up magnetic pole layer. Moreover, 1st layer partial 34a of the 2nd portion of a thin film coil consists of a portion of the shape of two or more square pole prolonged in the direction which intersects the space in drawing 12 (a).
[0120] Next, the insulating layer 24 which consists of an alumina is formed in the whole at the thickness of about 3-4 micrometers. Next, for example by CMP, an insulating layer 24 is ground and flattening processing of the front face is carried out until magnetic pole partial layer 15a and magnetic layer 15b of an up magnetic pole layer are exposed.
[0121] Next, magnetic pole partial layer 15a of an up magnetic pole layer and magnetic layer 15b by which flattening was carried out, and yoke partial layer 15c which forms the yoke portion of an up magnetic pole layer on an insulating layer 24 are formed in the thickness of about 2-4 micrometers.
[0122] Next, the insulator layer 25 which consists of an alumina is formed in the whole at the thickness of about 0.3-0.9 micrometers.
[0123] Next, although not illustrated, in the portion of the both-ends top in the each [ 4] -sided prism portion of 1st layer partial 34a of the 2nd portion of a thin film coil, a contact hole which penetrates an insulator layer 25 and an insulating layer 24, and reaches 1st layer partial 34a of the 2nd portion of a thin film coil by reactive ion etching or ion milling is formed.
[0124] Next, 2nd layer partial 34b of the 2nd portion of a thin film coil is formed by the frame

galvanizing method at the thickness of about 1.0-2.0 micrometers on the insulator layer 25 located on yoke partial layer 15c of an up magnetic pole layer. 2nd layer partial 34b of the 2nd portion of a thin film coil consists of a portion of the shape of two or more square pole prolonged in the direction which intersects perpendicularly with the space in drawing 12 (a). The both ends in the each [ 4] -sided prism portion of 2nd layer partial 34b of the 2nd portion of this thin film coil are connected to the both ends in the each [ 4] -sided prism portion of 1st layer partial 34a of the 2nd portion of a thin film coil through the connection section which it fills up with the material of a thin film coil, and is formed in the above-mentioned contact hole.
[0125] Next, the overcoat layer 27 which consists of an alumina is formed in the thickness of 20-40 micrometers, flattening of the front face is carried out to the whole, and the pad for electrodes which is not illustrated is formed on it. Finally, polish processing of a slider is performed, the pneumatic bearing side of a recording head and the reproducing head is formed, and the thin film magnetic head concerning the gestalt of this operation is completed.
[0126] Drawing 13 is the plan of the thin film magnetic head concerning the gestalt of this operation. In this drawing, an overcoat layer, other insulating layers, and the insulator layer are omitted. In this drawing, the sign 32 expresses the 1st portion of the thin film coil containing 1st layer partial 32a, 2nd layer partial 32b, and connection section 32c that connects these. In addition, in drawing 13 , a part of 1st portion 32 of a thin film coil is omitted. Moreover, the sign 34 expresses the 2nd portion of the thin film coil containing 1st layer partial 34a, 2nd layer partial 34b, and connection section 34c that connects these. 1st layer partial 32a of the 1st portion 32 of a thin film coil and 2nd layer partial 32b are connected with the JIGUZAKU form through connection section 32c. Thereby, the 1st portion 32 of a thin film coil is spirally wound focusing on 1st partial 8a of a lower magnetic pole layer. Similarly, 1st layer partial 34a of the 2nd portion 34 of a thin film coil and 2nd layer partial 34b are connected with the JIGUZAKU form through connection section 34c. Thereby, the 2nd portion 34 of a thin film coil is spirally wound focusing on yoke partial layer 15c of an up magnetic pole layer.
[0127] Moreover, the 1st portion 32 and 2nd portion 34 of a thin film coil are connected by the connection section 39. It fills up with the material of a thin film coil, and the connection section 39 is formed in a contact hole which penetrates an insulator layer 25, the record gap layer 14, and an insulating layer 13, and reaches 2nd layer partial 32b of the 1st portion 32 of a thin film coil.
[0128] As shown in drawing 12 , 2nd layer partial 32b of the 1st portion 32 of a thin film coil passes through the side of 2nd partial 8b of a lower magnetic pole layer. Moreover, 1st layer partial 34a of the 2nd portion 34 of a thin film coil passes through the side of magnetic pole partial layer 15a of an up magnetic pole layer.
[0129] According to the form of this operation, since a thin film coil has the 1st portion 32 spirally wound focusing on the lower magnetic pole layer, and the 2nd portion 34 spirally wound focusing on the up magnetic pole layer, compared with the form of the 1st operation, it can enlarge magnetomotive force of a thin film coil, and can raise NLTS and an over-writing property more.
[0130] The composition of others in the gestalt of this operation, the operation, and the effect are the same as the gestalt of the 1st or the 2nd operation.
[0131] this invention is not limited to the gestalt of each above-mentioned implementation, but various change is possible for it. For example, although the lower magnetic pole layer prescribed throat height, you may make it an up magnetic pole layer prescribe throat height with the gestalt of each above-mentioned implementation.
[0132] Moreover, although the gestalt of each above-mentioned implementation explained the thin film magnetic head of the structure which read to the base side, formed MR element of business, and carried out the laminating of the induction-type MAG sensing element for writing on it, you may make this built-up sequence reverse.
[0133] That is, it may write in a base side, the induction-type MAG sensing element of business may be formed, and MR element for reading may be formed on it. Such structure is realizable by forming in a base side by using as a lower magnetic pole layer the magnetic film which has the function of the up magnetic pole layer shown in the gestalt of the above-mentioned

implementation for example, and forming the magnetic film which has the function of the lower magnetic pole layer it was indicated to the gestalt of the above-mentioned implementation that countered it as an up magnetic pole layer through a record gap film. In this case, it is desirable to make the up magnetic pole layer of an induction-type MAG sensing element and the lower shield layer of MR element make it serve a double purpose.
[0134] Moreover, this invention is applicable also to the thin film magnetic head only for the records equipped only with the induction-type MAG sensing element, and the thin film magnetic head which performs record and reproduction by the induction-type MAG sensing element.
[0135]
[Effect of the Invention] As explained above, since a part passes through between the 1st and 2nd magnetic layers and it is spirally wound focusing on one [ at least ] magnetic layer, as for a thin film coil, according to the manufacture method of the thin film magnetic head according to claim 1 to 10 or the thin film magnetic head according to claim 11 to 20, reduction of the magnetic-path length of an induction-type MAG sensing element does so the effect of becoming possible. Moreover, the 1st portion to which the 1st magnetic layer counters some thin film coils according to this invention, It connects with the field by the side of the 2nd magnetic layer in the 1st portion, and has the 2nd portion which forms a magnetic pole portion. some thin film coils Since it is arranged in the side of the 2nd portion of the 1st magnetic layer, the effect that become possible to form the 2nd magnetic layer on a flat field, consequently reduction of the width of recording track of an induction-type MAG sensing element is attained is done so.
[0136] Moreover, according to the manufacture method of the thin film magnetic head according to claim 4 or the thin film magnetic head according to claim 14, since a thin film coil is spirally wound doubly focusing on the 2nd magnetic layer, the effect of becoming possible further to enlarge magnetomotive force of a thin film coil is done so.
[0137] Moreover, according to the manufacture method of the thin film magnetic head according to claim 5 or the thin film magnetic head according to claim 15, the effect of becoming possible to enlarge magnetomotive force of a thin film coil further since a thin film coil has the 1st portion spirally wound focusing on the 1st magnetic layer and the 2nd portion spirally wound focusing on the 2nd magnetic layer is done so.
[0138] Moreover, according to the manufacture method of the thin film magnetic head according to claim 6 or the thin film magnetic head according to claim 16 The 2nd magnetic layer is connected to the magnetic pole partial layer which forms a magnetic pole portion, and this magnetic pole partial layer. Since the end face of the side which has the yoke partial layer which forms a yoke portion, and counters the record medium of the yoke partial layer of the 2nd magnetic layer has been arranged in the position distant from the field which counters the record medium of the thin film magnetic head Furthermore, the effect that it can prevent writing data also in fields other than the field which should be recorded is done so.
[0139] Moreover, further, since according to the manufacture method of the thin film magnetic head according to claim 7 or the thin film magnetic head according to claim 17 the 2nd portion of the 1st magnetic layer specifies throat height and the 2nd magnetic layer specified recording track width of face, even if the width of recording track becomes small, the effect of becoming possible to be accurate and to specify throat height uniformly is done so.
[0140] Moreover, since the insulating layer to which some thin film coils arranged in the side of the 2nd portion of the 1st magnetic layer were covered, and flattening of the field by the side of a record gap layer was carried out was prepared according to the thin film magnetic head according to claim 8 or the thin film magnetic head according to claim 18, the effect that formation of a record gap layer, the 2nd magnetic layer, etc. becomes easy is further done so.

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[Translation done.]

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DESCRIPTION OF DRAWINGS

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[Brief Description of the Drawings]
[Drawing 1] It is a cross section for explaining one process in the manufacture method of the thin film magnetic head concerning the gestalt of operation of the 1st of this invention.
[Drawing 2] It is a cross section for explaining the process following drawing 1 .
[Drawing 3] It is a cross section for explaining the process following drawing 2 .
[Drawing 4] It is a cross section for explaining the process following drawing 3 .
[Drawing 5] It is a cross section for explaining the process following drawing 4 .
[Drawing 6] It is a cross section for explaining the process following drawing 5 .
[Drawing 7] It is the plan of the thin film magnetic head concerning the gestalt of operation of the 1st of this invention.
[Drawing 8] It is a cross section for explaining one process in the manufacture method of the thin film magnetic head concerning the gestalt of operation of the 2nd of this invention.
[Drawing 9] It is the cross section of the thin film magnetic head concerning the gestalt of operation of the 2nd of this invention.
[Drawing 10] It is the plan of the thin film magnetic head concerning the gestalt of operation of the 2nd of this invention.
[Drawing 11] It is a cross section for explaining one process in the manufacture method of the thin film magnetic head concerning the gestalt of operation of the 3rd of this invention.
[Drawing 12] It is the cross section of the thin film magnetic head concerning the gestalt of operation of the 3rd of this invention.
[Drawing 13] It is the plan of the thin film magnetic head concerning the gestalt of operation of the 3rd of this invention.
[Drawing 14] It is a cross section for explaining one process in the manufacture method of the conventional thin film magnetic head.
[Drawing 15] It is a cross section for explaining the process following drawing 14 .
[Drawing 16] It is a cross section for explaining the process following drawing 15 .
[Drawing 17] It is a cross section for explaining the process following drawing 16 .
[Description of Notations]
1 [ -- A lower shield layer 5 / -- MR element, 8a / -- The 1st portion of a lower magnetic pole layer,, 8b / -- The 2nd portion of a lower magnetic pole layer,, 10 / -- An insulator layer, 12a / -- The 1st layer portion of a thin film coil,, 12b / -- The 2nd layer portion of a thin film coil,, 13 / -- An insulating layer, 14 / -- A record gap layer, 15 ] -- A substrate, 2 -- An insulating layer,

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[Translation done.]